Application for Letters Patent
of the UNITED STATES OF AMERICA by -

LARS JOHANSSON
Bockfallsgard, Nykyrka
59 197 Motola
Sweden

Citizen of Sweden

For:

REFRIGERATOR WITH ADDITIONAL COOLING STEP

This application claims priority from Germany Application No. 102 55 833-7. filed November 29, 2002.

BACKGROUND OF THE INVENTION

The invention relates to a refrigerator in accordance with the preamble of claim 1.

Refrigerators quite in general can be distinguished by two different operating principles, name hand absorption refrigerators and compressor refrigerators. Absorption refrigerators generally are known and are described in WO 01/02723 A1 for example. In such refrigerators a working agent, in most cases ammonia, soluble in a solvent, in most cases water, is guided in circulation. Said circulation includes an expeller also referred to as cooker or pump, a condenser, an evaporator and an absorber. In the expeller the working agent is expelled from the solvent enriched with working agent with addition of external energy by a heater e.g. In gaseous state the working agent is transferred to the condenser by the expeller in which the working agent emits heat to the environment, cools down and finally condenses. The condensed working agent is transferred to the evaporator by the condenser, where it evaporates under absorption of heat on low level, e.g. in the evaporator of a refrigerator, and is transferred to the absorber in vapor state. In the absorber the working agent is absorbed in the solvent under emission of heat and then is retransmitted to the expeller, solved in the solvent, the described working cycle being closed thereby.

Refrigerators of this kind generally have proved efficient for a plurality of applications. However, these refrigerators include the drawback that they react on temperature variations somewhat lazy and in particular in the beginning of the cooling process make avail-

able only a limited cooling effect, this resulting in the cooling process requiring a certain period of time.

SUMMARY OF THE INVENTION

It is, therefore, the object of the present invention to improve a generic absorption refrigerator in such way that in particular in the beginning of the cooling process a more rapid cooling is rendered possible and that on the other hand the refrigerator can better balance temperature variations. Simultaneously, however, a simple construction and simple operation of the refrigerator are to be guaranteed.

This object is solved by a refrigerator showing the features of claim 1 and/or a method for operating said refrigerator, showing the features of claim 9. Preferred embodiments are subject of the depending claims.

The basis of the present invention is the conception that the desired properties of said refrigerator can be achieved in that an additional cooling step, a so-called booster, is provided for. Said additional cooling step operable completely independently from said first cooling means, an absorption refrigerating means in particular, then quite in general can be made use of for amplifying the cooling effect and/or for balancing temperature variations for all known refrigerators. Thus it is, e.g., no longer required to provide for an expensive control in the first cooling means, rather is it e.g. possible to operate a first cooling means in a refrigerator in comparatively constant manner, whereas a second additional cooling means, the so-called additional cooling step, can be switched on additionally if required. In

particular in the known absorption refrigerators this provides a particular advantage for the above-named reasons.

Since said second cooling means thus is to balance peak power, it is preferable that said second additional cooling means comprises a power spectrum permitting rapid reaction on temperature variations. Thus, a rapid cooling characteristic in particular is to be guaranteed by said second additional cooling means.

In the preferred application of said second additional cooling means, i.e. said second cooling step in an absorption refrigerator, it thus turned out to be particularly meaningful to embody said second cooling means as a so-called adsorption refrigerator in form of a zeolite refrigerator in which the adsorber material is formed by zeolites. This kind of cooling means namely is characterized in that when starting the cooling process very rapid cooling is permitted. The general disadvantage of adsorption refrigerators, namely the necessity of regeneration after a given period of time, is of no importance when used as additional second cooling step, as said second cooling step is not intended for continuous duty. Thus, the adsorption refrigerator has the possibility of regeneration at times when its operation is not required. Adsorption refrigerators also are generally known and e.g. described in DE 195 07 768 A1. Adsorption refrigerators in most simple form comprise an adsorber reservoir in which the adsorber material to which the working agent adsorbs is arranged, and a combined evaporator-condenser reservoir in which the working agent alternatingly evaporates with water absorption or condenses with heat emission. The working agent in the cooling process evaporates in the evaporator and is adsorbed on the adsorber material, whereas during regeneration the working agent now condenses in the evaporator or

condenser and is expelled by the adsorber material, namely usually by heat supply.

Since in the regeneration phase of said adsorption refrigerator warm water vapor is led into the evaporator or condenser of said adsorption refrigerator and for obtaining the cooling effect the evaporator has to be disposed in or on the cooling compartment, it is meaningful to already somewhat cool down and/or condense the water vapor prior to entry into the evaporator or into the condenser in order to avoid a too severe temperature load of the cooling compartment during regeneration of said adsorption refrigerator. For this purpose it is advantageous to provide for a heat exchanger outside of the cooling compartment, through which the vapor expelled from the adsorber material is guided in order to at first already emit a certain amount of heat. Alternatively it may also be meaningful to arrange the evaporator or condenser movably so that when used as evaporator the evaporator or condenser is arranged in or on the cooling compartment and when used as condenser it is arranged outside the cooling compartment.

Advantageously also a control is provided for, which controls the operation of the two cooling means, the absorption cooling means and adsorption refrigerator in particular.

Herein the control in accordance with a further aspect of the invention preferably is designed such that the two cooling means are simultaneously operated when the refrigerator is switched on and/or in case of increase of the temperature in the cooling compartment exceeding a given threshold value, whereas after lowering of the temperature in the cooling compartment below the given threshold value the second cooling means is switched off and/or is regenerated.

In case of an adsorption cooling means as additional cooling step this means in particular that upon the given threshold value being reached the second cooling means, i.e. the additional cooling step, is regenerated and then is kept in readiness for again being operated when the temperature increases.

For being able to keep the second cooling means in readiness it is advantageous to keep ready blocking means for either the evaporator-condenser reservoir, for the connecting line between adsorber reservoir and evaporator-condenser reservoir and/or adsorber reservoir in order to keep ready for us the condensed working agent, water in particular, for evaporation.

BRIEF DESCRIPTION OF DRAWINGS

Further advantages, characteristics and features of the present invention become evident from the following detailed description of an embodiment. The attached drawing in purely schematic manner shows a functional scheme of a refrigerator in accordance with the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

The refrigerator 1 shown in the drawing comprises a cooling compartment 2 which is to accommodate the goods or objects to be cooled. On said refrigerator two cooling units 3 and 4 are provided for which can cool said cooling compartment 2 in completely self-supporting manner.

Said cooling means 3 is formed by a known absorption cooling means, in the schematic drawing only the evaporator 5 within

said cooling compartment 2 being shown, whereas the remaining absorption cooling circuit is schematically taken into account as globule having reference numeral 7.

Said second cooling means 4 also referred to as additional cooling step, is embodied as so-called adsorption cooling means, namely as zeolite cooler in the preferred embodiment presented here. Said zeolite cooler 4 also comprises an evaporator 6 arranged in said cooling compartment 2. Said evaporator 6, however, as will be described later in more detail, in addition also serves as condenser so that here it is referred to as evaporator-condenser reservoir 6. Said evaporator-condenser reservoir 6 via a connecting line 11 is connected to the adsorber reservoir 8 in which the adsorber material, here zeolite, is received.

In said connecting line 11 in addition a valve 12 is provided for which permits to close said connecting line 11. Said valve 12 can be of any construction, a mechanical or an electrical valve in particular.

Furthermore, said connecting line 11 extends through a heat exchanger 10 arranged outside of said cooling compartment 2. In the schematic view of the attached drawing said connecting line 11 extends through said heat exchanger in straight manner and thus along shortest path. Of course, in a real embodiment said connecting line 11 will be guided through said heat exchanger 10 in turns e.g., in order to make available a surface as large as possible for said heat exchanger.

In the vicinity of said adsorber reservoir 8 in addition a heating means 9 is provided for which also can be realized by any known and suitable structural shape.

The shown refrigerator now works in such manner that when said refrigerator 1 is switched on, i.e. when starting said absorption cooling means 2, simultaneously said valve 12 in said connecting line 11 between said adsorber reservoir 8 and said evaporator-condenser reservoir 6 is opened. In this way the working agent, e.g. water, which in the beginning is in said evaporator-condenser reservoir 6 can move into said adsorber reservoir 8. The adsorber material accommodated in said adsorber reservoir 8 absorbs the water vapor being in the working chamber of said adsorption means 4, i.e. said evaporator-condenser reservoir 6, said connecting line 11 and said adsorber reservoir 8, so that a further evaporation of the water in the evaporator-condenser reservoir 6 is excited. By the evaporation of said working agent or water in said evaporator-condenser reservoir 6 heat is extracted from said cooling compartment 2 so that said cooling compartment 2 is cooled down.

Simultaneously by the operation of said absorption refrigerating circuit 3 by the evaporation of said working agent, e.g. ammonia, in said absorption refrigerating circuit 3 heat also is extracted from said cooling compartment 2 so that the cooling effect is amplified thereby. However, the efficacy and efficiency of said adsorption cooling means 4 is higher in the beginning of the cooling process so that at first said cooling means 4 contributes most of the cooling power.

After a certain period of time said adsorber material, i.e. the zeolites. in said adsorption reservoir 8 are saturated with water and

evaporation of water in said evaporator-condenser reservoir 6 comes to an end. However, at this time said cooling compartment 2 already is cooled down to a great extent and said absorption cooling means 3 has reached its optimum power. At this time then said adsorption cooling means 4 is regenerated in that said heating means 9 is operated and said working agent, i.e. the water, contained in said adsorber material is expelled therefrom by the heat. Through said connecting line 11 and thus via said heat exchanger 10 contributing to a first cooling down and/or condensation of said water vapor, the warm water vapor reaches said evaporator-condenser reservoir 6 in which now a condensation of said water vapor occurs. When almost all of the water or the water portion expellable with sensible expense evaporated and condensed in said evaporator-condenser reservoir 6, said valve 12 is closed so that the water or the water vapor can no longer reach the adsorber reservoir 8. Thus, said absorption cooling means 4 is prepared for a further cooling task. The latter may e.g. consist in that in case of an increase of temperature in said cooling chamber exceeding a given threshold value said adsorption cooling means 4 is additionally switched on using a control not shown.

By the additional cooling step in form of said additionally provided adsorption cooling means 4 in addition to said absorption cooling means 3 thus an improvement of said absorption cooling means is effected in such respect that on one hand a more rapid cooling down of said cooling chamber is rendered possible and that on the other hand better response on temperature variations is possible. In spite of the fact that in the shown preferred embodiment an adsorption cooling means is described as additional cooling step, it of course is conceivable that also another suitable cooling means is provided for, e.g. quite in general also other suitable cooling means are mutually combined in the shown manner.

As alternative additional cooling step also an additional absorption cooling means can be provided for instead of said adsorption cooling means 4, provided that this one has a more rapid cooling characteristic than said first cooling means. Here, in particular an absorption cooling means, e.g. a system with ammonia and salt, offers itself. Quite in general thus as second cooling means any kind of sorption cooling means can be made use of, which has a more rapid cooling characteristic than said first cooling means.